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THE REASONABLENESS OF SCIENCE[1]

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A Fable of the Tides

ONCE upon a time—for science also has its fables—there dwelt a hermit on the shore of the ocean, where he observed the tides. He measured the period and the range of their rise and fall and, patiently tabulating his records, discovered that the tides run like clock-work. The interval between two high tides was determined to be about 12 hours and 26 minutes; the range from low water to high water was found to vary systematically, being greater one week and smaller the next, the total variation running its course in 14 days; more singular still, the high tides were found to exhibit an alternating inequality, such that, if they were numbered in order, the even-numbered would be stronger than the odd-numbered for two weeks and then the odd-numbered would be stronger than the even-numbered for two weeks; this cycle of alternating inequality completing itself in 28 days. The hermit then wishing to extend his observations, decided to travel overland to another ocean and learn whether the tides behaved in the same way there also.

Now at the same epoch, but far away in the center of a great continental desert, a recluse lived in a cave, thinking and reflecting. One problem in particular engrossed his thoughts. He knew Newton's law of gravitation, and he asked himself what other consequences ought to follow from it besides the revolution of the planets around the sun and of the moons around their planets. He at last convinced himself that if the earth and the moon attract each other, the moon must produce a system of what he called earth-deforming forces, disposed in such a way as to strain the earth's crust, tending to raise it on the sides of the earth toward the moon and opposite the moon, so that at any one point on the rotating earth, the crust should be raised twice in a lunar day, or every 12 hours and 26 minutes; also, that similar but weaker earth-deforming forces produced by the sun should be combined with those produced by the moon so that the resulting total strains in the earth's crust would be stronger and weaker every 14 days; and furthermore, that as the moon is north of the sky equator for one half of a lunation and south of it for the other half—Alas, that you dwellers in roofed houses are so little acquainted with the sky as not to know of your own seeing that the moon's course does carry it obliquely across the sky equator and back again every month!—but as the moon does move in this manner, the recluse saw that the deforming forces which tend to raise the earth's crust at any point must exhibit a sequence of alternating inequalities every 28 days. And beside these rhythmic variations in a little more than half a day, in 14 days, and in 28 days, he worked out several other variations of even longer periods. But his calculations also showed that the rhythmic forces were too weak to deform the stiff earth's crust perceptibly. "If only," he thought to himself, "some large part of the earth's surface were covered with a deep sheet of water, surely the deforming forces would make the yielding water sheet rise and fall every 12 hours and 26 minutes, with a variation of range every 14 days, and an alternating inequality of rise every 28 days, and so on." He thereupon resolved to travel into other regions and learn, in case a vast sheet of water were anywhere discovered, whether it really did exhibit rhythmic changes of level in systematic periods such as, according to his calculations, it ought to exhibit.

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[1] Oration delivered at the annual meeting of the Harvard Chapter of Phi Beta Kappa, in Cambridge, Mass., June 19, 1922.

Observation, Invention and Deduction

Curiously enough it happened that about this time the hermit reached a caravansery where he met an alert-looking individual who proved to be an inventor—not an inventor of machines but of hypotheses and theories and explanations. The hermit told him about the tides and their periodic variations, and asked: "What do you suppose makes them go?" The inventor thought a moment and then said: "Perhaps the tides rise and fall because Old Mother Earth is slowly breathing; or perhaps, inasmuch as you say the tides vary every 12 hours and 26 minutes, or twice in a lunar day, they may possibly be driven by the moon." "How can they be driven by anything that is so far away in the sky, and why should one moon make two high tides in one lunar day?" asked the hermit. Just then the recluse came in and, approaching the other two, inquired: "Can you tell me whether there is anywhere a vast sheet of water covering a large part of the earth?" "Yes, there is," said the hermit; "it is called the ocean. I have lived on its shores, observing the periodic rise and fall of its waters in the tides and I was just asking the inventor here if he could tell me how they are caused." The inventor repeated his suggestion that the tides might possibly be caused by a sort of earth-breathing, but that they were more probably caused by the moon. "Well, as to that," exclaimed the recluse, "I can tell you how the tides ought to run if the moon has anything to do with them. The moon ought to produce two high tides on opposite sides of the earth, so that as the earth rotates, the tides at any one point ought to rise and fall twice in a lunar day, as you say they do; not only so, they ought to be extra strong every 14 days at new moon and at full moon, because the sun also must have a share in producing them; and besides that, the high tides ought to show an alternating inequality in a period of 28 days; and"—The astonished hermit interrupted—"They do exactly that," he cried, "but how in the world did you know they do so, if you have never seen the ocean?" "I didn't know they did," replied the recluse, "but I was convinced that *if* the earth had an ocean its waters ought to have rhythmic oscillations of the kind I have described, because don't you see——" and he proceeded to explain his calculations.

VERIFICATION

"What are you men talking about?" said a sedate-looking onlooker of judicial aspect. So the hermit, the inventor and the recluse all repeated their stories to him. He pondered a while and then remarked to the inventor—"It looks very much as if your hypothesis about the moon's driving the tides were correct, for it is hardly conceivable that the consequences of lunar attraction, as thought out by the recluse, and the period of the tides, as observed by the hermit, could agree so well unless the moon and the tides stood in a veritable relation of cause and effect; but the hypothesis needs modification because, as the recluse has pointed out, the secondary variations of the tides show that the sun also has something to do with them." "But," interposed the recluse, "there should be, besides those already mentioned, still other periodic variations in the tides if they are really caused by the moon and the sun, and it will demand of the observer at least a year to detect some of the longer ones." "Take your time," said the judicial onlooker, "go back to the ocean and make a long series of records, not only at one point but at many different points on widely separated coasts; and come back here for a second conference 10 or 20 years hence. We may then reach a well established conclusion."

And thus it came to pass that, after long series of tidal observations had been made in many parts of the world, all the rhythmic consequences deduced from the moon-and-sun theory were so fully confirmed by their correspondence with the observed periodic variations of the tides in the ocean, that—in short, it all ended happily: all the world was convinced that the moon and the sun really do drive the tides.

THE FOUR-FACULTY PROCEDURE OF MODERN SCIENCE

But the moral of the fable is yet to be told. The moral is that the observant hermit, the alert inventor, the thoughtful recluse, and the judicial onlooker represent not four different individuals, but only four different mental faculties in a single individual, the trained man of science, who uses his powers of observation to discover the facts of nature, his inventive ingenuity to propose various possible hypotheses for the explanation of the facts, his power of logical reflection to think out, or deduce, from each hypothesis, in accordance with previously acquired, pertinent knowledge, just what ought to happen if the hypothesis were true, and his impartial faculty of verification to decide which hypothesis, if any, is competent to explain the observed facts. In view of the leading part taken by these four faculties in scientific investigation, we may speak of science as involving a four-faculty procedure. But the fable must not be taken to mean that every scientist has all his faculties developed to the full strength needed for the best work; one man may be a patient observer but not active-minded enough to be a good inventor of hypotheses; another may be an ingenious inventor of hypotheses, but too impatient to be a good observer and too flighty to be a good deducer, and so on. Nor must it be understood that the several faculties work independently; as a matter of fact, now this faculty, now that is called into play in irregular sequence, and very frequently they are summoned into conference with one another. If it were not that the phrase is preoccupied in another connection, we might call such conferences "faculty meetings." Furthermore, it must be pointed out that replacement of mental deduction by experiment is essential in problems of certain kinds; that is, the faculty of invention is called upon, after proposing an explanatory hypothesis, to devise special artificial conditions under which natural processes shall themselves be permitted or constrained to determine the consequences of the hypothesis; but mental deduction usually accompanies or follows experimentation, and therefore problems into which experiment enters may still be included under four-faculty science.

THE FALLIBILITY OF SCIENCE

Unfortunately, in all steps of science from observation to verification, mistakes may be made, errors may creep in. It would be profitable to examine some of the more common classes of errors into which scientific investigators are led by the imperfection of their faculties; and it would be still more profitable to set forth the safeguards by which the danger of making errors may be lessened. Brief comment on observation and verification may be made in these respects. Errors commonly associated with observation result from the unconscious extension of visible things into inferred things, and from the attempt to establish generalizations on too narrow a basis. Consciousness of the danger of these errors goes far toward eliminating them. The most common errors associated with verification are a tendency to adopt an imperfectly supported conclusion instead of maintaining a suspended judgment, and an unwillingness, indeed an inability to change an adopted conclusion after it has been invalidated by new evidence.

As to the latter cause of error it may be said that, if proficiency comes from practice, it would be almost worth while occasionally to lead advanced students to a false conclusion and leave them in it for a time, so that they might have actual practice in changing their minds when corrective evidence is later brought forward. Indeed, scientific training can hardly be regarded as completed until it has included the necessity of giving up a cherished opinion. The experience is distinctly an unpleasant one; it causes mental disturbance to the point of sleeplessness; but it is profitable in promoting the maintenance of a mobile state of mind. Time forbids further consideration of this aspect of scientific methods; but I must again emphasize the undeniable and regrettable fact that, in spite of all efforts in training and safeguarding the mental faculties, it is still impossible to avoid all errors, because scientists are fallible; for if mistakes can be made with respect to anything so manifest as visible facts of observation, they are still more likely to be made when it comes to the invisible facts of theory. The marvel is not that mistakes of both kinds are made, but that, in spite of man's undeniable fallibility, so great a body of scientific conclusions still holds good, especially with regard to what I have just called the invisible facts of theory. Let me say a few words on that point.

THE NATURE OF THEORIZING

There is a popular prejudice against the use of the inventive faculty, ordinarily called theorizing. Theorizing alone, mere theorizing, is certainly of little value; but trained theorizing in proper association with trained observing is absolutely essential to scientific progress. The chief reason for this is that our observing senses are of limited power. We soon reach the conviction that many facts of nature elude direct observation, either because their medium is inherently transparent and intangible, or because their dimensions are submicroscopic, or because their time of occurrence lay in the irrecoverable past. And yet all of these unobservable phenomena are in their own way just as much a part of the natural world as observable phenomena are. If we wish really to understand the natural world, surely those of its phenomena which are not immediately detectable by our limited senses must be detected in some way or other; and the way usually employed is—theorizing. No single observable fact is a complete entity. The world is not so simply constituted. The deeper one inquires into the nature of an observable present-day fact, the more one becomes persuaded that it is in some way or other related to something else that, for the reasons just given, is not observable; and in such an inquiry one soon becomes convinced that the something else is, in spite of our not seeing it, or hearing it or feeling it, in short not sensing it, just as truly a fact of nature as the sensible fact from which our inquiry started out. The sensible facts are discoverable by our senses, the insensible facts by our thoughts. The invention of hypotheses is therefore nothing more than a mental effort to bring insensible facts into causal relation with sensible facts, and such an effort of correlation is praiseworthy even if it is daring.

Now hypotheses when first invented are as a rule not only incomplete, but are also without assurance of being true, especially with regard to insensible facts. Of course they must explain the observed facts that they were invented to explain; they would deserve no consideration at all if they did not do that! But before any one of several competing hypotheses is accepted as true, it must do more; it must explain facts that it was not invented to explain, facts that were perhaps not known when it was invented; and it must do this consistently with all previously acquired knowledge, so that the new explanation shall cohere with the older ones. Not until these exacting demands are satisfied should the correctness of even the best of several competing hypotheses be accepted. It therefore remains, after several hypotheses have been invented, to determine which one of them, if any, is right; that is, to determine whether the imagined insensible facts of any one of the hypotheses are truly counterparts of actual insensible facts. That important task is accomplished, as was shown in the tidal problem, by mentally deducing all the logical consequences of each hypothesis and then matching them with appropriate sensible facts. If the consequences of a hypothesis are numerous, peculiar and complicated, and if, even so, they succeed in matching equally numerous, peculiar and complicated facts, a good share of which were unknown when the hypothesis was invented, then it is highly probable that that hypothesis is true.

Let me add that it is this demand for the verification of a hypothesis after its invention that especially distinguishes modern science from primitive science, as I shall later show more fully; and it is chiefly because of the demand for verification that the modern progress made in the daring search for insensible facts has been so great. Errors are still made, because scientists are still fallible; but instead of pointing, I will not say the ''finger of scorn,'' but the thumb of reproach at science for having made and for still making errors, we should rather marvel at its successes, particularly in revealing to us the nature of the unseeable, insensible world, as in the inconceivably small subatomic electrons and ions which enter into the composition of the material substances of the world; or in the existence of the marvellously tenuous, elastic, and immaterial medium, named the luminiferous ether, by which radiant energy is conveyed through what we call empty interplanetary and interstellar space; or in the event of the past history of the earth's surface, which were visible enough in their time, but which are now irrecoverably invisible.

The Credulity of Science

It is not to be denied that much credulity is called for in this daring search for the unobservable facts of the natural world. Science, however, is not alone in credulously building up an unseen world to complement the seen world. That has been done by non-science also for ages past. But the credulity involved in the two cases is unlike. In the latter the credulity is whimsical, fantastic, irresponsible, incoherent; in the former it is orderly, controlled, rational, coherent. During the progress of the human race from savagery toward enlightenment, fantastic, incoherent credulity is slowly replaced by rational, coherent credulity. The belief in witchcraft is a good example of irrational credulity. Let me give you an equally good example of rational credulity. The solution of the tidal problem involves a belief in the force of gravitation, by which two bodies like the moon and the earth or the sun and the earth exert a pulling force upon each other. We are familiar with the exertion of a pulling force through material substance, as when one pulls a heavy body with a rope; but the attraction of the sun upon the earth is exerted through what appears to be empty space. Yet in spite of the absence of anything to pull with, the sun's attraction is strong enough to pull the moving earth continually into the curved path of its orbit. How large a rope or cable do you suppose would be required to represent, in material form, the pull exerted through empty space by the sun on the earth? If the cable were made of ordinary telegraph wires, the wires would have to be planted all over the earth's disc about as close together as grass roots in a lawn, and even then the wires would be stretched almost to breaking strength in compelling the earth to turn from a straight tangent into its curved orbit. Scientific credulity accepts that marvel. It believes that that enormous pull is exerted by the sun on the earth through space that is empty of all material substance, even though no adequate physical explanation is yet found as to how the pull can be exerted. Credulity of a certain kind is therefore highly characteristic of science and of scientific men; it leads them to believe marvels quite as marvellous as any that were ever believed in unscientific ages.

The Scheme of the Geographical Cycle

Let us now turn to an altogether different example of scientific inquiry, a geographical inquiry concerning the distribution of plants and animals over the earth's surface. Climate is an important factor in controlling their distribution. Now climate varies not only from equator to pole but also with altitude above sea level. Lowlands are warmer and as a rule drier than highlands. But a lowland may, it is believed, be changed to a highland by the gradual upheaval of its part of the earth's crust; and it is believed further that a highland thus produced must in the course of time be worn down to a lowland again by the still more gradual processes of erosion. A warm lowland with a moderate rainfall may therefore be upheaved into a cool or cold highland with greater rainfall; and after the forces of upheaval have ceased, the cool and rainy highland may be very slowly worn down to a warm and less rainy lowland again. Evidently there must be changes in the flora and fauna of a region while it is undergoing these changes of altitude and of climate. As a lowland is raised into a highland and its climate modified, its former flora and fauna can not survive, because they can not accommodate themselves to the new climatic conditions. They are therefore replaced by immigrants from some neighboring highland or from some lower land nearer the pole. Likewise the occupants of a highland can not survive the changes of climate that take place as it is worn down to a lowland; they are therefore gradually replaced by invaders from some other lowland not too far away. It is instructive to note that these changes of the earth's surface, slow as they may be, are faster as a rule than the evolutionary changes of plants and animals. Hence, in a long view of the earth one would see its plants and animals not only undergoing their extremely slow evolutionary changes, but also making somewhat less slow migrations, prompted by and accompanying the upheavals and down-wearings of its surface; and the present distribution of plants and animals is believed to be simply a transitory phase in this long succession of changes.

How different is this problem of the cycle of geographical changes from that of the tides. The rapid changes of the tides are directly observable; they are moreover periodic and their changes can therefore be observed over and over again; and both they and their cause are susceptible of quantitative mathematical treatment. The changes of the geographical cycle are so slow that they can not be followed, they can only be imagined; and there is no reason for believing that such cycles of change are accomplished in a definite period, nor indeed that any given cycle will run its entire course without disturbance; the downwearing of a highland to a lowland may be interrupted during its progress by a new upheaval. Moreover the asserted extinctions and invasions of plants and animals following the changes in the climate of their habitat are only inferences. In a word, this scheme of the geographical cycle is in its very nature highly speculative. Why then should credence be given to it? For the very simple reason that only by believing it can a host of present-day observable facts, inorganic and organic, be brought into reasonable relations. In short, the scheme of the geographical cycle is believed because it works; and therefore, like many other scientific conclusions, it is an excellent example of pragmatic philosophy. But how venturesome is a scheme in which the observed facts of to-day constitute so small a fraction of the total phenomena! On the other hand, for those who have the scientific faith to believe that such changes as those involved in the scheme of the geographical cycle have actually taken place in the evolution of the present aspect of the earth, how admirably does this scheme give us examples of invisible facts of theory! And in spite of their being deeply buried in the past, how wonderfully are those facts recovered, at least in their general nature, by taking that mental action which, although it does not add a cubit to our physical stature, does add immensely to our understanding.

THE NATURE OF SCIENTIFIC DEMONSTRATION

But what does a man mean when he says that he believes the scheme of the geographical cycle, with its imagined yet unseen changes of land forms and its inferred yet unobserved changes in the distribution of plants and animals. He ought not to mean that the truth of the scheme has been absolutely proved, but only that it has been given a very high order of probability; for that is, as a rule, the nature of what is often called scientific demonstration. He ought to recognize also that many generalizations on which the argumentation of the scheme rests are likewise not absolutely proved: for example, the persistence of the present-day order of natural processes through hundreds of millions of years of past time; to says nothing of the unbroken continuity of time itself! Who can prove the truth of those generalizations in any absolute sense? Nevertheless one accepts their truth because he finds, after due inquiry, that they too appear to have a high order of probability.

Now what is the common feature in the problem of the tides and the problem of the geographical cycle, and in all other scientific problems, in virtue of the possession of which they deserve to be called scientific? Evidently not the subjects that they treat, for the subjects of scientific study are remarkably diverse. The common feature inheres not in the content of the problems but in their method; and the common feature of their method is the quality of reasonableness; that is, a spirit of free inquiry, in which no prepossessions are accepted which are not themselves open to scrutiny, in which the conclusions reached are followed wherever they lead, and in which a revision of conclusions is made whenever it is demanded by new facts. Science is therefore not final any more than it is infallible. It is a growth, and its growth is by no means completed.

Science had indeed only very gradually grown to be the four-faculty procedure that it now is. In very primitive times the mere observation of facts without inquiry as to cause was perhaps as far as science could then be carried; it was only a one-faculty procedure then. Somewhat later simple generalizations regarding facts that resembled each other may have been made; and the generalizations framed by individuals may have advanced to tribal generalizations. Indeed it seems quite possible that some such tribal generalizations of one-faculty science, for example, as to things that are good and bad to eat, may have been established by our anthropoid ancestors before they deserved to be called men. But even the most primitive tribes of men now living seem centuries ago to have advanced into a second stage of two-faculty science, in which the invention of explanatory hypotheses is added to observation and generalization. Even the lowest savages now known try to explain many of the things that they see by relating them to other things that they either see or do not see, and they thus establish to their own satisfaction relations of cause and effect. If the effect is explained by a visible cause, well and good. But if, in the stage of two-faculty science, the effect is explained by an invisible cause, what then?

The Two-Faculty Procedure of Primitive Science

In striking contrast with present-day four-faculty science in which verification is so essential, the earlier two-faculty stage of science accepts its hypotheses without any adequate verificatory inquiry. Its explanations do not have to explain more than they were invented to explain, and they do not have to cohere with previously acquired knowledge. If they explain the facts that they were invented to explain, that is enough. Naturally therefore the two-faculty stage of science represents a phase of human development in which whimsical, incoherent credulity flourishes, the kind of credulity which I have already referred to as unscientific, because it is so unlike the orderly, coherent credulity of four-faculty science. But I now wish to treat that incoherent credulity in another way; to regard it as the inevitable accompaniment of two-faculty science, and hence just as appropriately an element of an early stage in the evolution of science as the rational, coherent credulity is of the present, more advanced stage. It is as if, between the primitive one-faculty stage, which was reasonable as far as it went, and the present four-faculty stage which seems to those who have reached it completely reasonable, there had been an unreasonable two-faculty stage in the evolution of science. The three stages are so unlike that one might hesitate to call them all scientific; just as one hesitates to give a single name to a caterpillar, a chrysalis and a butterfly: and yet the first two stages are in both cases the essential antecedents of the third. In any case the two-faculty stage of science was as reasonable as the two-faculty scientists could make it; and that is all we four-faculty scientists can say of our own stage.

The Natural History of Goodness

This may be made clearer by illustration. At the opening of my address I outlined the problem of the tides as one which modern four-faculty science has carried to a well established quantitative solution. This was followed by the problem of the geographical cycle which, although avowedly very speculative, has been advanced to a qualitative solution at least. I wish now to consider a third problem, which illustrates remarkably well the gradual development of inquiry in ancient times, and also the difference of certain conclusions reached by two-faculty science that was in vogue then from those reached by four-faculty science that is current now; and this problem has the further value of illustrating the optimism of science, for it leads to a conclusion concerning mankind that is full of hope. The usual name for the subject of this third example is the science of ethics; I propose, however, to call it in general terms the natural history of goodness. There is nothing new in what I have to say on this old subject, although I may give a new emphasis to some of its aspects.

The facts which this branch of natural science treats are found in the body of opinion held by the different tribes and peoples of the world concerning things which they regard as right and wrong, that is, in their moral codes, and in the actions which they approve or condemn. Different people have different codes, and the code of the same people changes with the passages of time. Countless are the tragedies that have been enacted when a more powerful people, arrogantly assuming the justice of its own code, has ruthlessly violated the code of a weaker people. The theoretical side of the science includes a search for the sources of the different elements of each tribal or national code, for the processes by which the elements of a code are slowly modified, and for the forces by which good thoughts and acts may be fostered and bad ones suppressed. The natural history of goodness is therefore concerned with the concrete opinions and actions of ordinary men in commonplace, every-day life, and has nothing to do with the abstractions of metaphysics regarding absolute and eternal ideals. In that respect it might be compared with the natural history of mathematics, which would portray the efforts of early man in gradually and tentatively developing the multiplication table, but would have nothing to do with the metaphysical pre-existence and everlasting verity of 7 times 9 being 63. For in the same way the natural history of goodness would, if it could, describe the first recognition and the later modification of various ethical principles by certain peoples in certain places at certain times under certain conditions, but it would take no acocunt of the metaphysical view that all ethical truths are eternal, as if they had existed by themselves somewhere in the interstellar spaces of the universe for untold ages awaiting recognition.

THE ETHICS OF THE CHILDREN OF ISRAEL

The few illustrations of this great subject that I have time to present will be taken from the Old Testament, that marvellous record of the intensely human struggle made by a primitive and ignorant people in their advance from savagery to barbarism. How very primitive they were; and in no way more primitive than in candidly recording their frequently scandalous behavior! A more sophisticated people would have taken care to conceal their errors, but the Children of Israel were savagely naïve. Their early books, those of the Pentateuch and the ones next following, contain abundant material for study in announcements concerning things held to be right or wrong as affecting food and hygiene, property in land, cattle and slaves, safety of life and limb, and social intercourse. The good things are sometimes directly stated, but they are more often to be inferred as the opposites of bad things that are prohibited or punished.

None of the announcements are more striking than those which have to do with the taking of human life as a punishment for various kinds of wrong-doing. In the time of Noah this important problem was treated simply and concisely: ''Whoso sheddeth man's blood, by man shall his blood be shed'' (Gen. ix, 6). But that early pronouncement was elaborately modified in the time of Moses and afterward. It was then still ordained in general terms that ''thou shalt give life for life;'' but it was also ordained on the one hand that, besides offenses of bloodshed, various other offenses should also be punished by death, and on the other hand certain offenses of bloodshed should not be punished by death. As to the first, a number of offenses are listed, among them being for example the smiting or the cursing of one's father or mother, for which a man ''shall surely be put to death'' (Ex. xxi, 12-17); and here the use of the word ''surely'' seems to imply that the Children of Israel were sometimes too lax in the punishment of such offenders. As to the second group of offenses, a time came when careful distinction was made between intentional and accidental manslaughter. Thus if one man thrust another out ''of hatred, or hurled at him, lying in wait, so that he died,'' that man is a manslayer and ''the avenger of blood shall put the manslayer to death, when he meeteth him.'' This command is emphasized by the suggestive addition: ''Ye shall take no ransom for the life of a manslayer (Num. xxxv, 20, 21, 31). But a man who ''killeth his neighbor unawares, and hated him not in time past; as when a man goeth into the forest with his neighbor to hew wood, and his hand fetcheth a stroke with the axe to cut down the tree, and the head slippeth from the helve, and lighteth upon his neighbor, that he die;'' then the man is not worthy of death, inasmuch as he hated not his neighbor in time past (Deut. xix, 4, 5, 6). At an early time one witness seems to have been sufficient to prove a man to be a manslayer; but in later time it is said: ''At the mouth of two witnesses or three witnesses, shall he that is to die be put to death; at the mouth of one witness he shall not be put to death'' (Deut. xvii, 6). What good, homely common-sense this is!

Ancient and Modern Views of Israelitic Ethics

It would appear from these and many other passages, especially those concerning their wars, that the Israelites must have been indeed a violent crew; but it appears also that they made very explicit and frank record of their views concerning right and wrong. Now if we examine their records as contributions to the natural history of goodness in an era of two-faculty science, we ought to ask ourselves among many other questions, not only what were the views of the Israelites concerning good and evil, but also how they gained their views, and how they came to establish, as a means of controlling their actions for the common weal, rewards for good and punishments for evil. As a matter of fact, investigation of this large subject has been carried on earnestly for a century or more, and in a truly scientific spirit; that is, reasonably and with an open mind. I propose to compare, or rather to contrast, the conclusions reached by modern students of the subject under their four-faculty procedure, with the opinions held by the Israelites themselves under their two-faculty procedure.

The Israelites' view was, if we are to take their records literally, that their understanding of good and evil as well as their decrees for the reward of good and the punishment of evil, came to them by supernatural revelation; and this view was adopted by all Christendom in later centuries. The modern view, more and more widely adopted now, is that the Israelites derived their knowledge and their decrees concerning good and evil in a perfectly natural way from a perfectly natural source; namely, from their own perfectly natural experience, the same source from which all other human knowledge is gained. The decrees and commandments were not sudden acquisitions, but merely expressions of the morals and customs gradually developed among the people and formulated by their leaders. In comment upon these two views it should be noted that the ancient view originated among a primitive, ignorant, cruel, self-centered people, very ready to adopt extraordinary, even supernatural explanations for simple occurrences, because being in the stage of two-faculty inquiry they did not apply, they did not know how to apply independent verificatory tests to their hypotheses, but naïvely believed them if they explained the things they were invented to explain; and that the modern view has been gradually developed in later times by many broadly informed students of human history and human nature, who have gathered a vast amount of information not only about the ancient Israelites but also about many other primitive peoples, ancient and modern; students who have examined that information reasonably and in a spirit of free inquiry, who have at every step in their inquiry done their best, according to the procedure of four-faculty science, to verify their explanations and who have therefore reached their conclusions carefully and critically, intelligently and sympathetically.

Grounds of the Modern View

Some persons here present probably hold the earlier one of the two views, and some the later one; but however my audience is divided in that respect, it is more likely a unit in not habitually looking on the Old Testament as affording material for the scientific study of the natural history of goodness, and as therefore not regarding it as affording fit illustrations for the third example of scientific inquiry, which I am now outlining. There seem nevertheless to be cogent reasons for looking on it in this way. One of these reasons is that the Old Testament, especially its earlier half, gives so excellent an idea of the manner of life led by the Children of Israel. The records are as a whole unconcealedly human in telling of friendships and quarrels, of generosities and meannesses, of honorable acts and of dishonorable acts; hence they give an invaluable picture of the views of a primitive people on moral questions.

Furthermore, when the books of the Old Testament are read—particularly when they are read in a polychrome edition which distinguishes the various sources from which the successive books are compiled—the understanding of good and evil there recorded is seen to exhibit very distinctly an evolutionary progress, such as is found from studies of other peoples to be characteristic of the natural history of goodness in general; witness the citation already made about manslaughter; witness also the declarations concerning food. In the time of Noah it was said: ''Every living thing shall be good for you'' (Gen. ix, 3); and this is much more primitive than the later declaration in the time of Moses, when sharp discrimination was made between the cloven-footed, cud-chewing animals which might be eaten and other kinds of animals which might not be eaten (Lev. ix; also Deut. xiv). It may be noted in passing that a belief in the evolutionary development and progress of mankind greatly simplifies the vexatious problem of the existence of evil in the world; for much of the forbidden behavior or wickedness of a later era is thus seen to be only a continuation of the permitted behavior of an earlier, less advanced era.

Finally, the Old Testament records of the Children of Israel may be taken as affording proper material for the study of the natural history of goodness because they show the Israelites to be so very like other savage races. They justified themselves as a chosen people; they ascribed bad qualities to their enemies whom they really resembled rather closely; they saw mysterious omens in commonplace events; they regarded dreams as messages from an extra-human source; they were miraculously visited by good and bad spirits; they took their own very human convictions to be revelations and commandments from their local tribal god; and to that god they attributed, but in a higher degree, their own very human qualities; not only wisdom and goodness and power, but also forgetfulness, repentance, hatred and revenge. In all this the Children of Israel are so like other primitive tribes that they must evidently be studied just as other primitive tribes are studied.

Supernatural and Natural Interpretations

Now in reviewing the reasons thus briefly set forth for regarding the records of the Old Testament as affording fit material for the study of the special branch of human evolution here under consideration, it is interesting to notice that the same reasons lead to the rejection of the older view that the knowledge of good and evil gained by the Israelites was derived from a supernatural source, and to the acceptance of the modern view that it was simply a summation of their own human experience. Indeed, when the Mosaic books are read in a rational, scientific spirit, without prepossession, the marvel is that they can be interpreted in any other way. That the Israelites should have introduced supernatural elements into their records, as when they explained the Ten Commandments by revelation, is inevitable in view of what is now known concerning the natural history of goodness among all primitive peoples in the stage of two-faculty science; and that they should have accepted these supernatural elements as true is thoroughly characteristic of the incoherent credulity that prevails among primitive peoples under the two-faculty method of establishing beliefs in unseen things. But that the supernatural elements of these ancient and primitive beliefs should have been accepted as true by all Christians during nearly all the centuries of Christendom is nothing less than marvellous; or perhaps I should say, would be nothing less than marvellous did we not know that through all those centuries a great part of the beliefs of Christendom were dominated by two-faculty science.

Consider, for example, the decree concerning a servant who has earned his freedom by six years of service, but who then still loves his master, his wife and his children so much that he does not wish to go out free and leave them: in that case "his master shall bring him . . . to the door, or to the door post; and . . . shall bore his ear through with an awl; and he shall serve him for ever" (Ex. xxi, 6). Boring a hole through a man's ear with an awl would seem to be a very simple, a very human way of marking him. It is therefore unduly credulous to believe that this and other similar decrees had a supernatural source, even if they are preceded by the introductory statement: "And the Lord said unto Moses, these are the judgments which thou shalt set before the Children of Israel" (Ex. xxii, xxiii). No such introductory statement is given before similar decrees in Deuteronomy xv. One is indeed tempted to think that the words, ''And the Lord said . . . '' by which various paragraphs in the Pentateuch open, were hardly intended to be taken literally.

The Treatment of Enemies

If anything more is needed to show the utterly human nature of the Mosaic decrees, it is found in the narrow limitation of the commandments: ''Thou shalt do no murder . . . Thou shalt not steal;'' for manifestly these rulings applied only to neighbors and fellow tribesmen, not to enemies. As to enemies, commands were repeatedly given, as if from the Lord, to kill them wholesale, even to their women and children; and to steal from them everything they possess. The advance of the Israelites to the promised land under Moses and Joshua is a horrible story of rapine and bloodshed; the plain and pitiless story of ruthless savagery. Samuel is probably remembered by most persons nowadays chiefly as a gentle little boy, who, wakened from his sleep by the call of the Lord, answered, ''Speak, for thy servant heareth'' (I Samuel iii, 10); yet it was Samuel who, when grown to manhood, was possessed with the idea that the Lord gave him a message, a hideous message, to Saul, to smite the Amalekites ''and utterly destroy all they have, and spare them not; but slay both man and woman, infant and suckling, ox and sheep, camel and ass.'' And because Saul and his army, after killing every man and woman, infant and suckling, spared Agag the king of the Amalekites and kept the best of the oxen and sheep for themselves, ''then came the word of the Lord unto Samuel, saying, It repenteth me that I have set up Saul to be king . . . and Samuel was wroth'' and had Agag brought before him and hewed him in pieces with a sword (I Samuel xv, 3, 11, 33).

A Great Debt to Science

We have sadly to admit that horrors of those kinds have been frightfully characteristic of human progress from savagery and barbarism all over the world; and also that such horrors have been frequently regarded by the people who committed them as acceptable to or directed by their local tribal deities, as they conceived them; but it must have been a heavy burden to Christian faith to believe that the loving, fatherly God of the New Testament is the same god who led Joshua in his bloody wars and who told Samuel to give that hideous message to Saul. It is a great blessing that the progress of modern scientific inquiry and the spirit of rationalism that has grown with it have relieved Christian faith of that burden. Science has truly benefited the world in many ways, but it may be doubted whether any other benefit derived from scientific rationalism is so great as the liberation of Christianity from the reproach which it fully deserved so long as it included a literal acceptance of all the teachings of the Old Testament, in spite of Christ's preaching a religion of brotherly love in the New Testament.

But you may ask, is it truly to science that the world owes that great benefit? Has science indeed anything to do with these religious matters? It has of course to do with the earth and the stars, with plants and animals, with steam and electricity; but by what right does science concern itself with questions of good and evil? It does so by the same right, precisely the same right that it studies the tides as governed by the moon and the sun, and the slow changes of earth's surface when lowlands are raised to highlands and when highlands are worn down to lowlands. For the observant and thoughtful study of mankind discovers many facts of opinion and facts of action concerning things that are regarded as good or bad; and all those facts, which together with their causes and consequences are included under the natural history of goodness, are just as properly open to scientific inquiry, that is, to unprejudiced, reasonable inquiry, as any other facts in the world. Nevertheless, the feeling that science is a trespasser on such ground is often met; and also the allied feeling that science is too cold and hard to deal with such questions. Let us see.

THE CONFLICT OF RELIGION AND SCIENCE

First, as to science being a trespasser when it touches questions with which religion has traditionally dealt. Much has been written about what is called the conflict between religion and science. The cause of that conflict lay not in the trespass of science upon the proper field of religion, but in the trespass of religion upon the proper field of science. Religion attempted, while thus trespassing, to dictate beliefs concerning the age of the earth, the origin and the antiquity of man, and many other mundane matters. What is more natural than that science, as it developed, should enter into conflict with the trespasser; and what more manifest now than that, in so far as geology and organic evolution and other similar subjects are concerned, the conflict should have resulted in the complete conquest of those subjects by science from religion! This wholesome defeat of religion, or rather of the misguided defenders of what was long thought to be religion, would not have taken place had the advice of St. Augustine been followed. He wrote long ago: "It very often happens, that there is some question as to the earth or sky, or the other elements of this world . . . respecting which one who is not a Christian has knowledge derived from most certain reasoning or observation, and it is very disgraceful and mischievous and of all things to be carefully avoided, that a Christian speaking of such matters as being according to the Christian Scriptures, should be heard by an unbeliever talking such nonsense, that the unbeliever perceiving him to be as wide of the mark as east from west, can hardly restrain himself from laughing'' (Thus quoted in Osborn's ''From the Greeks to Darwin'').

Will not a modern St. Augustine arise and make a similar statement concerning the natural history of goodness? I wish he would, for all human thoughts and acts are, like human anatomy and physiology, the product of natural evolution. Just as surely as all questions of a geological or astronomical or biological nature have now been permanently acquired from religion by their respective sciences, so conquest will be made of all questions concerning right and wrong by that division of science which concerns itself with the natural history of goodness as a matter of purely human experience, in contrast to goodness as a matter of supernatural revelation. Two great and growing, though still young branches of modern science will contribute powerfully to this conquest; they are eugenics and psychiatry. I hope that some speaker before this society a hundred years hence will review the practical contribution by that time made to human betterment by these young giants.

TRUE SCIENCE IS NEITHER COLD NOR HARD

As to the other idea that science is too cold and hard to deal with moral questions, there is to my regret some ground for that opinion. It is probably based on the behavior of certain scientists who, having made, as far as they have gone, no serious misjudgments, have not been enlightened by the baptism of acknowledged error, and who are therefore harshly overconfident of the correctness of their conclusions. They introduce their would-be rigorous methods of thought into daily intercourse with their neighbors, and are logical when they ought to be genial, argumentative when they ought to be sympathetic; in short, they are very tiresome fellows, and they do science a disservice. No wonder that a gentle-minded person would hesitate to trust scientists of that sort with decisions on delicate problems of right and wrong! But on the other hand, even the best of science is judged cold and hard with little reason by certain sentimental and emotional persons who, reclining on soft couches of prejudice and downy pillows of preference, are intellectually too indolent to face the problems of life fairly and squarely; too unreasonable to subject their opinions to candid scrutiny; too undisciplined to change their beliefs even in the light of compelling evidence. They know nothing of the calm and clear spirit of free inquiry; they are unwilling to follow free inquiry to an unwelcome conclusion; for example, they reject the philosophy of evolution because, as they fastidiously phrase it, they do not like the idea of being descended from monkeys. I do not believe we need take their condemnation of science as being cold and hard any more seriously than their rejection of evolution because they do not like it.

No, the natural history of goodness lies manifestly within the field of scientific inquiry, and true scientific inquiry will not be either cold or hard in reaching conclusions about it. Scientific inquiry will, indeed, remove from the minds of intelligent thinkers at least, a very cold and hard religious view of ancient origin to the effect that punishment, either in this world or in hell, is the best means of suppressing evil; and will also remove, I hope, the equally primitive view that rewards, either in this world or in heaven, are the best means of promoting good. And let me note in passing that the dependence of the Israelites largely upon punishment, and frequently upon very harsh punishment, as a means of improving human behavior is another of the many evidences for the human origin of their code of morals. It is natural enough that crude views regarding the wish for reward and the fear of punishment should have been characteristic of ignorant ancient peoples, just as they are still characteristic of unintelligent modern peoples. But it is clear enough to-day that fear of punishment is often unsuccessful in the prevention of evil, and that expectation of reward, especially of distant reward, is not very successful in the promotion of good. There is great need of finding something better than reward and punishment as a means of improving the world.

Can the scientific study of the natural history of goodness discover something better? It ought at least try to do so; and in the belief that it will do so lies the optimism of science; but it will take a long time to reach results. For as I have already noted the natural history of goodness includes a study of the forces by which good thoughts and actions may be encouraged and strengthened, and bad ones inhibited. How will the study proceed? Undoubtedly by the standard scientific method of observation, invention, deduction including experiment, and verification; in a word, reasonably. The facts to be studied are, of course, plainly enough very unlike the visible and periodic variations of the tides as controlled by the moon and the sun, and very unlike the present distribution of plants and animals as a consequence of the long past, invisible, non-periodic changes of the geographical cycle; but just as certain appropriate means have been found for solving those unlike problems under the four-faculty proceedure of modern science, equally appropriate means will, it must be hoped, be found for the solution of this human problem. Efforts toward its solution by the current methods of improving personal and public morals as a part of religious training will of course be continued; but I hope they may be supplemented by systematic instruction in ethics as a branch rather of natural history than of philosophy in schools and colleges.

GOODNESS TAUGHT BY THE CASE METHOD

In such instruction the nature of the subject should not be set forth so much in impersonal generalizations as by the "case method," the same method which Louis Agassiz so successfully introduced into the study of zoology, which Langdell with equal success applied to the study of law, and which is now increasingly employed in the Harvard Graduate School of Business Administration as the best means of inculcating sound business principles. Indeed, the natural history of goodness lends itself remarkably well to this method of presentation; for its facts may be set forth in collections of concrete examples of various kinds of behavior, concerning which the pupils may make their own judgments and generalizations; and such collections of examples may be graded from elementary to advanced, so as to afford excellent material for individual exercises from early school years onward. But in the meantime, while such instruction is going on, the specialists in this branch of natural science must extend their investigations by carrying their observations over a great number of individuals, and by devising ingenious experiments concerning all sorts of pertinent conditions.

Observation will be difficult because it will have to take account of the endless diversity in the dispositions and capacities of boys and girls, men and women; but it must not be neglected. Experiments will be intricate, for they will operate slowly and will be hard to follow; but they must not be omitted. Both observation and experiment must be directed in particular to determining how far the love of goodness and the hatred of evil can be cultivated and strengthened; and also how far the cultivated love of goodness and the spiritual happiness that comes from good deeds, together with the cultivated hatred of evil and the spiritual distress that comes from bad deeds, may be trusted as guides to conduct, in preference to rewards for good behavior and punishment for evil-doing; and in this investigation due regard must be had to the age and the nature and the environment of the individual. Great results should not be expected, however, until a way is discovered to strengthen the will; and I believe the best way to do that will be to give it opportunity for action in a carefully devised and wisely supervised series of graded exercises, running all through school and college years. We are making a very serious mistake in not introducing systematic exercises for the development of the will, that is, of self-control, in our educational system.

Objection will probably be urged against the proposition to teach goodness as a branch of natural history. It will be said that the omission of all mention of God is fatal to its acceptance and its success. In my judgment, our relation to the Infinite should be excluded from natural history and assigned to religious instruction, where it should be treated with the utmost reverence; while the natural history of goodness should be taught just as other branches of natural history are taught, entirely apart from any idea of special creation or any miraculous interference with the order of nature. But it should be taught with a gentleness, a delicacy, a sympathy not to be imagined by persons who think of science as cold and hard, and of scientists as chiefly engaged in hammering rocks, dissecting animals and pulling plants to pieces. Those who enter this branch of natural history, either as investigators or as teachers, must strive to conduct themselves with the wisdom of the judge, the true insight of the poet, when need be with the tenderness of a mother, and always with the infinite patience of evolution itself. It is a great field and it deserves the devotion of the best minds.

THE GREATER FAITH OF DEVOUT BELIEVERS

In order to illustrate the reasonableness of science I have told you something of the tides as a very specific, quantitative, mathematical problem of four-faculty science; and I have sketched the scheme of the geographical cycle as a highly speculative problem, in the qualitative treatment of which the four-faculty procedure has nevertheless been encouragingly successful. Finally I have outlined the natural history of goodness in order to exemplify the broad range of moral questions over which the four-faculty method of scientific inquiry may be hopefully extended. You will, I trust, accept the tides and the geographical cycle as problems of some interest and importance; but I hope you will regard the natural history of goodness as a much more interesting and a much more important subject of scientific study, particularly as an illustration of the reasonableness of science. If you do so, I beg that you will encourage the cultivation of that branch of natural history and favor its introduction, by means of the case method, into our educational system. There will be of course, as already intimated, those who will say that, just as in replacing special creation by evolution, so in replacing the revelation of goodness by its experiential development, we are acting as if we had lost faith, as if we were unbelievers; but for my part I hold that we are thus acting as most sincere, most earnest, most devout believers, and as having the greater faith.